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ALGAE AS BIOINDICATORS FOR ASSESSMENT AND MONITORING THE WATER QUALITY WITH SPECIAL REFERENCE TO DUHOK'S DRINKING WATER PLANT

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ABSTRACT

The physical, chemical, and biological parameters have been studied at six selected sampling sites in the Duhok Drinking water plant within Duhok city. Algal and water samples were collected monthly from October 2021 to September 2022. The water temperature ranged from 8.1 to 22.5 ^{0}C. The pH values varied from 7.31 to 8.93. Specific electrical conductivity ranged from 328.1 to 472.6 µs cm^{-1}. Alkalinity values ranged from 120 to 195 mg/L $CaCO_3$. Total hardness varied from 184 to 250 mg/L $CaCO_3$. Silicate values ranged from 67.89 to 120.01 mg/L. Phosphate concentrations ranged from 0.01 to 0.73 mg/L. Values of nitrate varied from 2.3 to 5.8 mg/L. A total of 58 algal taxa were identified during this study, which belong to four divisions: 25 taxa belong to Bacillariophyta, making up 43% from the all; 21 taxa belong to Chlorophyta, making up 36% from the all; 7 taxa belong to Cyanophyta, making up 12% from the all; and 2 taxa belong to Euglenophyta, making up 3.5%. 2 taxa belong to Dinoflagellata, making up 3.5% from the all; 1 taxa belong to Xanthophyta, making up 2% from the all.

***KEYWORDS*:** Algae, Bioindicator, Monitoring, Water quality, Duhok**.**

1. INTRODUCTION

Water is the most important component in all biological processes and activities. Freshwater organisms' environments are influenced by both biotic (organism-related variables) and abiotic (water-related) factors. Long-term and short-term analyses of water benefit from monitoring an aquatic ecosystem (Adakole and Anunne 2004). Location and climatic conditions are just two of the variables that affect water quality fluctuations (Pellerano *et al.,* 2002). The bio-geochemical cycle, as well as industrial and agricultural processes, can be linked with the presence of fertilizers and micro-nutrients in water (Enache *et al.,* 2009).

The first level of the food chain and the primary producers in the aquatic ecosystem are algae. As a result, both quantitative and qualitative analyses of the algal flora are very important. There are substantial differences across the sites in the qualitative and quantitative patterns of algal dispersion (El-Awamri *et al.,* 2005). Algae play a significant role in aquatic ecosystems because their abundance, distribution, quantity, and production, serve as indicators of the health of their surroundings. Algae are essential for detecting water contamination and cleaning wastewater (Leghari and Shah 2002; Sigee 2005; Soylu and Gönülol 2003; Wan Omar 2010). Algal groupings, abundance of species, and diversity are all decreased by water pollution (Wan Omar 2010). Numerous studies have demonstrated a correlation between the cation and anion concentrations and the community and abundance of certain algae (Potapova and Charles 2003). Consequently, the goal of the present study is to determine the limnological parameters (algological water quality) of the source of water at Duhok's drinking water plant, which constitutes one of Duhok's most important drinking water projects in the region, and to identify the algal species composition and abundance.

2. METHODOLOGY

2.1. Study Area

The Project area is located within Dohuk governorate. Duhok's Drinking Water Plant is located within Semel District before the Mosul Dam Lake. This vital plant lies in the Northern Temperature Zone between the East Longitudes of 43^0 10' E and 44^0 10' E and the North

Latitudes of 36^0 40' N and 37^0 20' N. Mosul Dam was constructed on the Tigris River. Construction began on January 25, 1981, and the lake opened on July 7, 1986. It is the largest freshwater body in the Duhok district; the Tigris River is the source of the lake. It is suitable for fishing and farming economically important vegetables (Figure1).

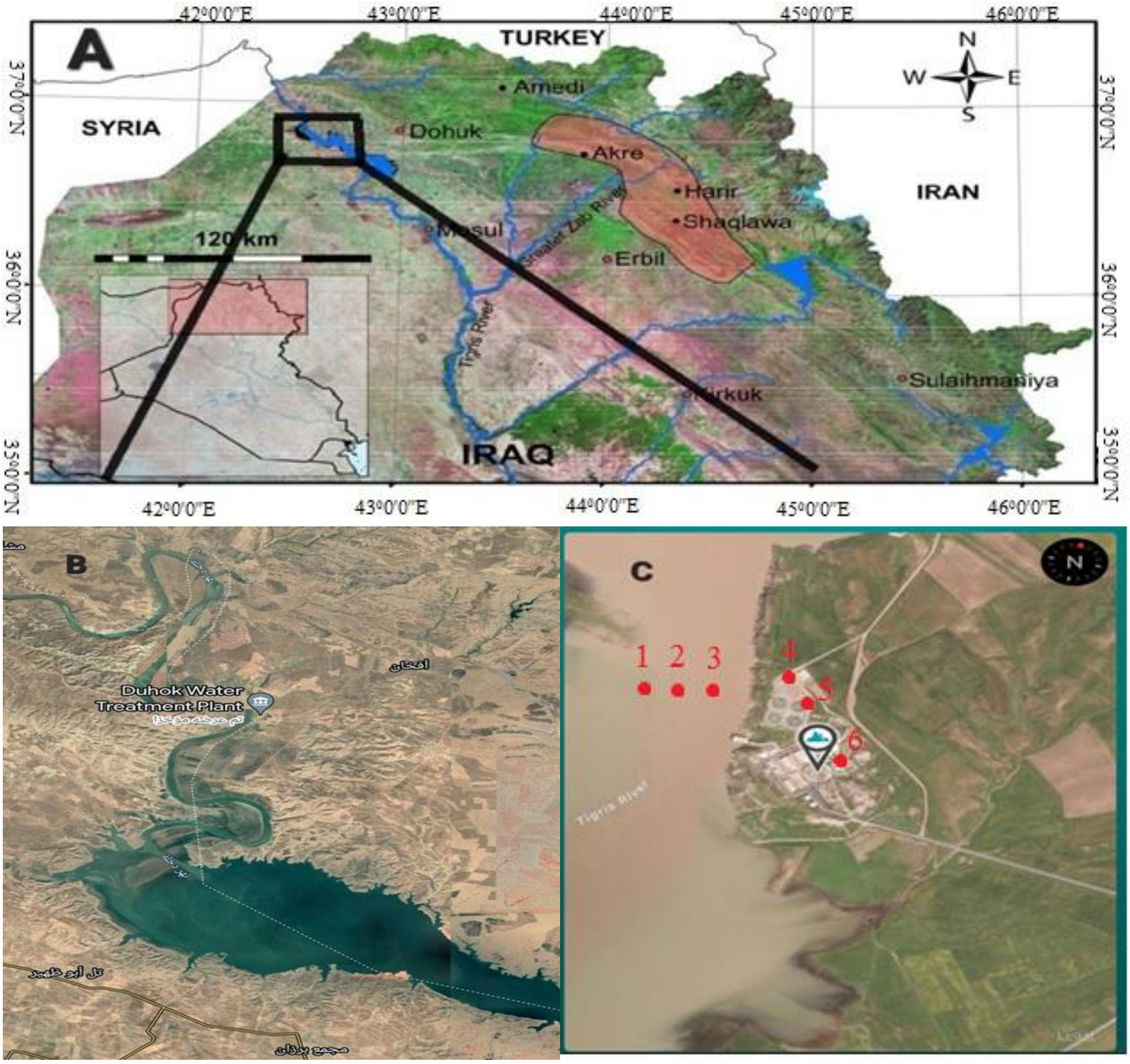

Fig. (1): Show map of: **A**- Northern part of Iraq, **B**- Location of Duhok water treatment plant, **C**- Location of sites (1 to 6) (Region-iraq and Zebari 2013).

2.2. Climate of studied area

Winter season in the Iraqi Kurdistan region are chilly and snowy, while summer season are considered dry and warm. The plains experience typical semi-arid climatic conditions. The rainy season started from October to May. In the Kurdistan region, there was a significant connection between the number of rainy days and geographic (height) regions (Ismail, 1994). It is important to note that almost all the major Tigris rivers crossing the study area come from Turkey and Syria (the Khabour river and the Fishkhabour river) (Fadhil 2011).

2.3. Materials and methods

Algal and water samples were collected monthly from October 2021 to September 2022. Some physical parameters were recorded for each site directly in the field, while other chemical parameters were measured in the lab. Water temperature, pH, and conductivity were measured directly in the field by using a pH/Cond. meter (JENWAY 430). Chemical and biological analysis was done at the lab, most of chemical analysis were done according to (A.P.H.A. 1998). The collection of phytoplankton was done using a phytoplanktonic net with 30 cm pore size. Collected algal samples were preserved with 40% formaldehyde. Identification and classification of algae was made up at the species level in most cases and was dependent on the following references (Evans and Prescott, 1956; Patrick and Reimer, 1966; Lawson and Rushforth, 1975; Zealand, 2000; Cronberg, 2006; Solak and Wojtal, 2012; Soler *et al.*, 2012; Poland and Ojtal, 2014; Potapova, 2014; Rosen and St. Amand, 2015; S *et al.*, 2015; Solak *et al.*, 2016). Complete randomized design (C.R.D.) was used in the statistical analysis, which was done using Microsoft's SPSS Version 22. The mean was compared using the Duncan test multiple ranges at level 0.05.

3. RESULT AND DISCUSSION

Based on the physical and chemical parameter values recorded during the study period and shown in (Table1and 2), the water temperature varied between 8.1 and 22.5 °C. The minimum water temperature was recorded in January 2022 at site 1, which was significantly different from all other studied sites, while the maximum water temperature value was calculated in June 2022. The maximum value of temperature was recorded in the summer months and the minimum value in the winter months. Based on the region's climate, which is of the Irano-Turanian type, the temperature of the air always affects the temperature of the water in Iraq (Zohary 1950). The variance in water temperature is influenced by the local climate. This is influenced by a variety of environmental elements, including wind, sunlight direction, water current velocity, elevation, and the annual range of atmospheric temperatures (Fattah, 2010).

The pH of water plays a significant role in determining its biological and chemical characteristics. It has an impact on numerous chemical compounds in water in their chemical forms. Additionally, pH affects how many dissolve and precipitate of metals, as well as how volatile, ionized, and toxic some dissolved compounds are to aquatic life (Fattah, 2010). Potential of hydrogen ion concentrations during the sampling period were shifted toward the alkalinity side of neutrality; this may have occurred as a result of the geological formation, minerals, and soil characteristics of the studied area, which are primarily made of $CaCO_3$, as shown by all of (Toma, 2011b, 2013). The lowest mean value of pH was measured in May 2022, which was significantly different from April, June, July, September, and October but not significantly different from all other studied stations. Flooding of the Tigris River brought significant levels of allochthonous materials to

Table (1): Maximum and Minimum value, Mean of physical and chemical parameters between studied sites for Duhok's Drinking Water Plant

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Water temperature ^{0}C	(8.1-20.8)	(8.2-20.7)	(8.3-20.6)	(8.4-20.5)	(8.3-21.1)	(8.3-22.5)
	15.38	15.44	15.44	15.37	16.03	16.20
	a	a	a	a	a	a
pH	(7.62-8.93)	(7.41-8.77)	(7.34-8.49)	(7.33-8.68)	(7.31-8.44)	(7.39-8.43)
	8.35	8.18	8.05	7.84	7.86	7.89
	a	ab	a-c	c	bc	bc
Specific E.C	(328.1-472.6)	(346.9-469.3)	(343.5-467.7)	(372.5-471.5)	(370.2-471.7)	(354.7-455.5)
(µs. cm$^-$1)	425.67	417.13	416.74	424.60	416.58	416.46
	a	a	a	a	a	a
Alkalinity	(125-180)	(120-195)	(120-190)	(130-195)	(125-190)	(120-180)
(mg/L $CaCO_3$)	165.50	168.33	168.33	171.67	165.00	157.50
	a	a	a	a	a	a
Total Hardness	(200-250)	(196-248)	(190-244)	(191-248)	(197-248)	(184-248)
(mg/L $CaCO_3$)	223.58	223.25	225.17	226.25	225.92	223.67
	a	a	a	a	a	a
Silicate (mg/L)	(76.95-118.08)	(78.49-118.58)	(81.76-120.01)	(78.98-119.40)	(77.67-118.71)	(67.89-111.06)
	95.58	97.30	98.87	97.09	96.14	90.26
	a	a	a	a	a	a
Phosphate (mg/L)	(0.02-0.55)	(0.01-0.73)	(0.05-0.63)	(0.05-0.46)	(0.06-0.63)	(0.02-0.11)
	0.16	0.17	0.26	0.19	0.22	0.06
	ab	ab	a	a	a	b
Nitrate (mg/L)	(2.5-5.6)	(2.7-5.8)	(2.7-5.7)	(2.8-5.8)	(2.7-5.74)	(2.3-5.23)
	4.09	4.19	4.21	4.14	4.11	3.77
	a	a	a	a	a	a

Table (2): Maximum and Minimum value, Mean of physical and chemical parameters between studied months for Duhok's Drinking Water Plant

Parameter	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Water temperature ^{0}C	(8.1-8.4) 8.27 h	(12.5-13.4) 13.00 f	(11.8-12.9) 12.28 g	(14.3-15.3) 14.78 e	(18.7-20.1) 19.45 b	(20.5-22.5) 21.03 a	(17.9-18.8) 18.28 c	(17.2-18.6) 17.85 c	(16.2-18) 16.88 d	(15.9-16.6) 16.25 d	(15.6-16.9) 16.33 d	(12.5-14.7) 13.30 f
pH	(7.34-7.79) 7.59 f	(7.42-8.24) 7.84 d-f	(7.50-8.16) 7.73 ef	(7.87-8.65) 8.28 a-c	(7.33-8.03) 7.71 ef	(7.85-8.53) 8.18 b-d	(8.36-8.68) 8.44 ab	(7.61-8.54) 8.01 c-e	(8.27-8.85) 8.55 a	(8.01-8.93) 8.41 ab	(7.31-8.12) 7.73 ef	(7.71-8.09) 7.86 d-f
E.C (µs. cm^{-1})	(418.1-473.2) 451.12 ab	(403.2-433.1) 419.42 c	(379.5-460.6) 432.43 bc	(369.1-427.8) 384.26 d	(328.1-372.5) 357.11 e	(444.2-471.7) 465.7 a	(430.4-438.5) 435.43 bc	(416.2-425.7) 420.6 c	(406.1-434.8) 424.41 c	(455.5-472.6) 466.06 a	(372.7-394.6) 382.33 d	(372.8-429.1) 395.43 d
Alkalinity (mg/L $CaCO_3$)	(140-170) 153.33 e	(155-170) 161.67 de	(160-190) 179.17 ab	(160-176) 171.00 b-d	(175-185) 180.00 b	(175-195) 183.33 a	(170-185) 176.67 a-c	(160-175) 169.17 cd	(160-195) 179.17 ab	(170-190) 178.33 a-c	(120-130) 123.33 g	(125-145) 137.50 f
Total Hardness (mg/L $CaCO_3$)	(204-220) 212.33 c	(220-248) 230.33 ab	(232-248) 240.00 a	(224-244) 233.33 ab	(222-232) 227.83 b	(226-244) 236.00 ab	(225-236) 230.50 ab	(220-240) 232.33 ab	(244-250) 240.33 a	(200-222) 215.67 c	(184-206) 195.33 d	(196-212) 201.67 d
Silicate mg/L	(111.06-120.01) 117.64 a	(90.97-96.55) 94.62 a	(101.23-107.86) 105.60 a	(74.37-79.25) 77.62 a	(88.71-91.46) 90.03 a	(67.89-81.76) 77.37 a	*	(101.56-111.24) 106.47 a	(104.50-115.60) 111.43 a	(93.79-102.84) 99.79 a	(75.07-86.40) 82.15 a	(83.70-95.40) 91.88 a
Phosphate mg/L	(0.08-0.33) 0.22 b	(0.06-0.18) 0.12 bc	(0.02-0.47) 0.16 bc	(0.07-0.31) 0.20 b	(0.06-0.22) 0.15 bc	(0.05-0.15) 0.09 bc	(0.01-0.06) 0.04 c	(0.03-0.14) 0.09 bc	(0.04-0.22) 0.15 bc	(0.11-0.73) 0.52 a	(0.02-0.21) 0.14 bc	(0.05-0.56) 0.23 b
Nitrate mg/L	(3.8-4.3) 4.05 de	(3.6-3.8) 3.72 f	(4.7-5.2) 5.02 b	(3.45-4.6) 4.17 cd	(3.67-4.05) 3.88 ef	(3-3.5) 3.31 g	(3.95-4.4) 4.23 cd	(4.45-5.2) 5.00 b	(4.1-4.6) 4.40 c	(5.23-5.8) 5.65 a	(2.3-2.8) 2.62 i	(2.83-3.1) 2.99 h

the lake, which caused the pH value to decrease (Abowei 2009) or might have occurred due to the reaction between acidic components and humic acids with contaminants in the lake (Shashi *et al*,. 2009) and (Olajire and Imeokparia 2001). In contrast to the highest mean value recorded in September 2022, this could be because the carbonate concentration has increased (Goran, 2006) (Abdulwahid, 2008) (Ibrahim, 1981) and (Al-Nakshabandi, 2002).

According to the concentration and mobility of the ions, specific electrical conductivity is a numerical measure of an aqueous solution's capacity to transmit an electrical current (A.P.H.A, 1998). The geological condition of the area through which the water travels has the biggest impact on conductivity in rivers and streams (Spellman, 2008). Specific electrical conductivity in particular did not go below 328.1 (µs. cm^{-1}) and did not exceed 472.6 (µs. cm^{-1}). This variation across the studied period was likely caused by variations in climate, geological formation, lithology, and the concentrations of the principal cations, calcium and magnesium. Similar observations were made by (Toma, 2011a) in Dokan Lake. At site 1, it was evident that anthropogenic discharge greatly enhanced the conductivity of the water samples. The lowest mean was in May 2022, which was significantly different from all other studied months. The highest mean of months was in October 2022, which was significantly different from all other studied months.

Alkalinity values ranged from 120–195 mg $CaCO_3$/L; the lowest mean was recorded in November 2021, which was significantly different from all other studied months. The highest mean for months was recorded during June 2022, which was not significantly different from March, July, September, October, and significantly different from other studied months. According to the results obtained in this investigation, positive correlations were noticed between total alkalinity and specific electrical conductivity with correlation coefficients ($R = 0.479$) and total hardness with correlation coefficients ($R = 0.867$) (Figures 2 and 3). This meant that the trends of specific electrical conductivity, total hardness, and alkalinity were similar, same result obtained by (Hassan *et al*., 2008).

About total hardness, the lowest mean was calculated in November 2021, which was not significantly different from December 2021, but it was significantly different from other studied months. The highest mean values measured of months was in September 2022, which was not significantly different from March, June, July, and August and significantly different from other studied months. Calcium and, to a lesser extent, magnesium in solution are the main contributors to water hardness. Typically, it is stated as the corresponding amount of calcium carbonate (Organization 2008). Hardness depends on temporal variations noticed during the research period. A high peak in total hardness was observed in September 2022, possibly due to the high alkalinity that was observed in that month, and a low value was observed in November 2021, possibly due to a dilution in ion concentration during the beginning of the rains, same results were obtained by (Kurunc *et al*., 2005). The classification of water depending on hardness was done according to (Spellman, 2008), the studied lake was hard water.

Silicate does not naturally occur as free silica but rather as free silica (SiO_2) in coarsely crystalline (rock crystal, quartz, etc.) and micro-crystalline (flint, jasper, etc.) variants of quartz. Silicate is combined with additional elements. Additionally, silicates can be found in rocks including shale, granite, and basalt. H_4SiO_4 and H_3SiO_4 are the two most typical aqueous forms of silica. For most plants, it is regarded as a trace element that is not necessary, but it is necessary for diatoms (A.P.H.A. 1998). The lowest mean value of silicate was in June 2022, which was not significantly different from all the studied months. The highest mean value of silicate was in January 2022, which was not significantly different from all the studied months. The maximum mean value stated in January might have been brought on by increased weathering in the river's watershed. The reduction in silicate concentration from April to June may have been caused by increased water discharge and velocity and an increase in phytoplankton, particularly diatoms (Cetin and Sen 2004), in the studied area.

Phosphorus, which is a limiting nutrient in aquatic environments, is present as phosphate. Major sources of phosphates include municipal wastewater discharges, fertilizer and feedlot runoff, and detergents (Spellman, 2008). Orthophosphate reacts with several different cations (A1, Fe, Ca) to generate very insoluble products and rapidly binds to clay. It is significantly less mobile than nitrogen in the sediments and precipitates more easily (Lampert and Sommer 1997). The minimum month mean value was July 2022, which was significantly different from December, January, April, and October and was not significantly different from other studied months. While the maximum month mean value was October 2022, which was significantly different from all other studied months. In the present investigation, reactive phosphate fluctuated between 0.01 and 0.73 mg/L P-PO_4. According to the results of this research, the highest mean value observed in October may have resulted from allochthonous phosphate compounds that were found in urban wastewater and agricultural runoff, including detergents used to wash clothing and dishes, occurring in the stream bank. While July saw the lowest mean, this could be because of a low dilution rate. My findings were verified by (Adeyemo *et al.*, 2008) they discovered elevated phosphate levels during the rainy season.

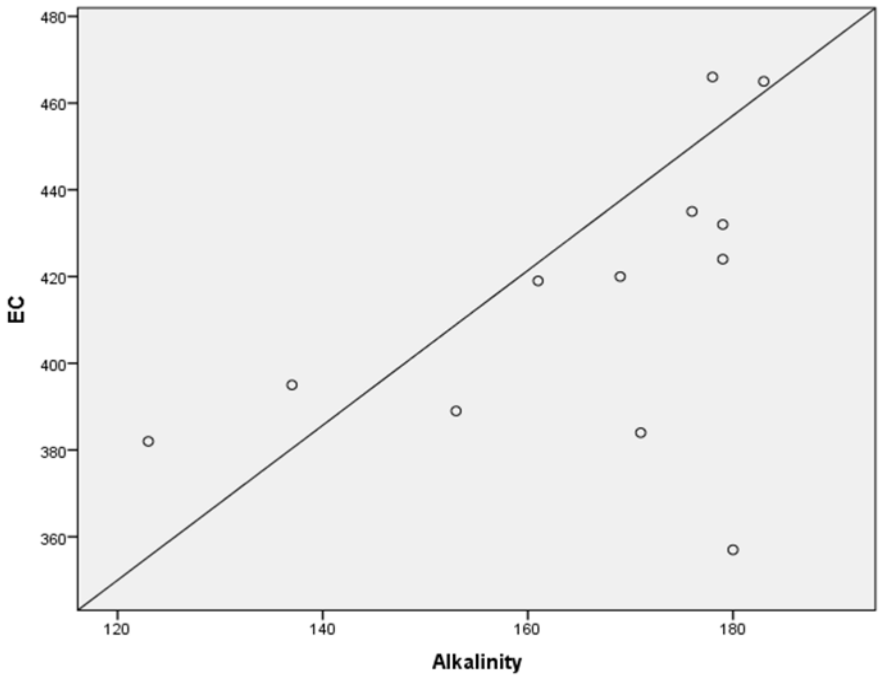

Fig. (2): Linear correlation between means of alkalinity and specific electrical conductivity.

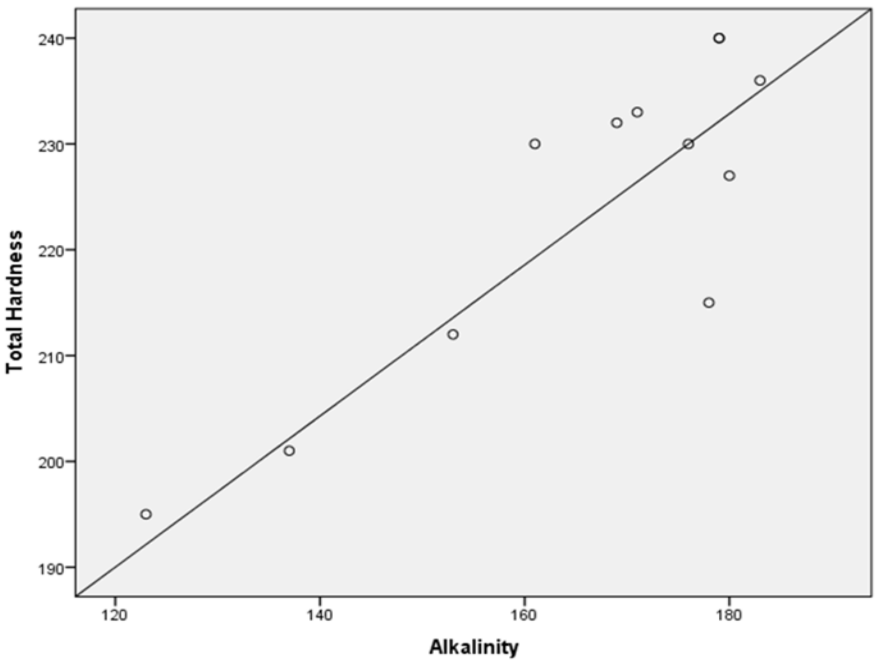

Fig. (3): Linear correlation between means of alkalinity and total hardness.

Nitrate is the common type of inorganic nitrogen in water (Spellman, 2008). Nitrate is the most extensively oxidized form of nitrogen compounds and is frequently present in surface and ground waters due to the fact that it is the end product of the aerobic breakdown of organic nitrogenous materials (Bartram *et al.,* 1996). Ions of nitrate are extremely soluble in water. As a result, excessive nitrates can easily permeate soils and go into aquifers (Walker *et al.,* 2019). Among the sources of nitrates are drainage from cattle feedlots and areas where animal manure is stored, runoff from fertilized, cultivated, and crop land, and wastewater from household, sewage, and some industrial waters (Bartram *et al.,* 1996; Olajire and Imeokparia, 2001) and (Spellman, 2008). The minimum mean value of nitrate was recorded in November 2021, which was significantly different from all other studied months. The maximum mean value of nitrate was recorded in October 2022, which was significantly different from all other studied months. The findings of this study showed a distinct regional fluctuation, with the highest mean value measured in October, which may be related to sewage and municipal wastewater flows into the river. (Adedokun *et al.,* 2008) were confirmed by my findings and stated that locations with strong population pressure and agricultural expansion have significant nitrate contamination of surface water. (Walker *et al.,* 2019) showed that although nitrate content in surface water is often low, it can increase due to pollution from human and animal waste and runoff from agriculture. Temporal fluctuation was also noted during this investigation; the highest mean value was discovered in October, either because of a high concentration of dissolved oxygen or because of allochthonous nitrate compounds from agricultural and land runoff. (Hassan *et al.,* 2008) showed that high levels of nitrate in both winter and spring may be caused by high levels of oxygen that are dissolved in the water and are a result of land drainage, sewage discharge, and urban run-off. While in November recorded the lowest mean, this may be because of the high water level, my findings were confirmed by (Adeyemo et al. 2008) and stated low of nitrate concentration recorded in rainy season.

A total of 58 algal taxa were identified, which belong to Bacillariophyta (25 taxa), Chlorophyta (21 taxa), Cyanophyta (7 taxa), Euglenophyta (2 taxa), Dinoflagellata (2 taxa), Xanthophyta (1 taxa). It is clear that diatoms comprised 25 taxa, making up 43% from all, whereas Chlorophyta make up 42% from all, Cyanophyta make up 12%, and Euglenophyta make up 3% from all. All identified algae were listed in (Table 3). Bacillariophyta present mostly in all studied months, opposite of Xanthophyta and Euglenophyta were rare present in August only. Filamentous Chlorophyta are represented by species of *Spirogyra*, *Cladophora*, *Oedogonium*, and *Ulothrix*. *Rhizoclonium* All of these filamentous green algae were detected during the spring and summer seasons. Chlorophycean development especially in summer and they removed from river by runoff event in the wet and floods season. *Cladophora* was observed mostly in all periods of the studied months, and *Spirogyra* was detected mostly in all periods of the study except March, June, and December. *Rhizoclonium* was detected only in October 2022. *Oedogonium* was detected only in April 2022. *Ulothrix* was detected only in July 2022, all of these algae can be found in alkaline flowing water from oligo-mesotrophic to heavily polluted water. Planktonic green algae are represented by *Pediastrum*, *Closterium*, and *Cosmarium*. *Pediastrum* was detected throughout the studied period only in November 2021, while *Closterium*, which belongs to the family Desmidiaceae, was detected mostly in the spring and summer seasons throughout the studying period. *Cosmarium* was observed in only one species in August 2022, may be due to the differences in physico-chemical properties, or may be due to presence of high electrical conductivities, magnesium, and nitrate. Cyanophyta are represented by *Oscillatoria* was detected mostly throughout the study period, while *Microcystis* was detected just in November and December 2021. *Fischerella muscicola* and *Stigonema ocellatum* were found in July 2022, thus their appearance due to high nutrient concentration detected in that months. Euglenophyta represented by *Euglena gracilis* and *Euglena deses* in the present investigation, which were found only in August 2022, may be due to the contamination found in that month. (Javed 2006) supported my results that *Euglena* regarded to be resistance to against heavy metal contaminations. (Bilgrami and Saha, 2004; Lelková *et al.*, 2004) stated that *Euglena* found in contaminated water. Phytoplankton in the studied area were dominated quantitatively by diatoms, and among diatoms, Pennales was dominant in planktonic forms. A total of 25 planktonic diatoms were identified, belonging to

19 genera from the Pennales and Centrales. Pennales diatoms make up almost the main bulk of Bacillariophyta in the present study. The genera with the highest species that were identified in the present study were: *Cymbella* (3 species), *Navicula* (2 species), *Melosira* (2 species), *Fragilaria* (2 species), *Cymatopleura* (2 species), and other 14 taxa. The results of identified algal species there is no new recorded according to last check list (Check List of Algae in Iraq) by (Maulood *et al.*, 2013). The ability of different algal species to adapt to environmental factors, including the chemistry of the water, sunlight, temperature, inorganic nutrients, organic nitrogen and carbon, oxygen level, pH, type of substrate, current velocity, and grazing activity, determines the composition of planktonic communities and the persistence of algal species (Stevenson *et al.,* 1996; Moonsyn *et al.*, 2009). (Salomoni and Torgan 2008) confirmed that physico-chemical analyses are typically used to evaluate water quality in aquatic ecosystems. These analyses provide information only on environmental conditions at the time of the measurements that were performed. Diatoms in particular can provide more detailed information on potential environmental changes that might have happened recently as well as in the present through the investigation of biological factors. (Cetin and Sen 2004) were drawn to the conclusion that interactions among physical and chemical factors are responsible for the diversity of species and seasonal variation of planktonic and benthic forms in freshwaters. According to the findings of this study, Pennales comprise the majority of Bacillariophyta, while Centrales were present during the investigation period but in much smaller numbers. *Melosira*, a type of diatom that belongs to Centrales, is seen to be more prevalent in planktonic communities during the summer than during the other studied months, possibly due to the slow flow of the Tigris River's. According to (Hassan *et el.*, 2008), the pinnate form of diatoms is consistent with Shatt Al-Hilla's fast-flowing characteristics. The results of this research showed that *Cymbella*, *Navicula*, *Melosira*, and *Fragilaria* were the most prevalent and diverse genera found. These genera are calcareous (alkaliphilous), and the study water was abundant in them because of the area's geology and high $CaCO_3$ content, same result concluded by (Çelekli and Külköylüoğlu 2007) and (Muhammad, 2004). According to findings observed from this study, the most common identified diatoms belong to the family Fragilariaceae, which is the most diverse family in terms of species number. *Fragilaria crotonesis* was the most detected species at all of the studied months, with the exception of October 2022, which was dominated by the species *Diatoma vulgare* due to the fact that *Diatoma* are more tolerated and adapted to environmental factors. (Walsh and Wepener 2009) they stated that *Diatoma vulgare* was detected with urban sites. (El-Awamri *et al.*, 2005; Pérez et *al.*, 2009) conducted that *Nitzschia* and *Navicula* were the most abundant genera at all of studied localities. All identified algae were represented in plates (1, 2, and 3). All measurements were given in µm.

Tabel (3): List of algae identified during studied period.

Months / Species	2021		2022									
	Nov.	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May.**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**
Cyanophyta												
Class: Cyanophyceae												+
Order: Hormogonales												
Suborder: Homocystineae												
Family: Oscillatoriaceae												
Osillatoria spp.	+	+	+	+	+	+	+		+	+	+	
O. subbrevis	+		+			+		+	+	+	+	
O. limosa	+		+	+		+	+	+	+	+		+
Order: Chroococcales												
Family: Microcystaceae												
Microcystis aeruginosa	+	+										
M.aeruginosa F. flos aquae	+	+										
Order: Stigonematales												
Family: Stigonemataceae												

Stigonema ocellatum									+			
Order: Nostocales												
Family: Hapalosiphonaceae												
Fischerella muscicola									+			
Chlorophyta												
Class: Chlorophyceae												
Order: Cladophorales												
Family: Cladophoraceae												
Cladophora spp.	+	+	+	+	+	+	+		+	+	+	+
C. fracta			+	+	+	+			+	+	+	
C. fracta var. normalis			+	+	+	+			+	+	+	+
C. crispata			+	+	+	+			+	+		+
Rhizocolonium hieroglyphicum												+
Order: Chlorococcales.												
Family: Hydrodictyaceae												
Pediastrum simplex	+		+									
P. duplex	+											
P. boryanum	+							+				
Family: Botryococcaceae												
Botryococcus braunii	+											
Order: Zygnematales												
Family: Zygnemataceae												
Spirogyra spp.	+		+	+		+	+		+	+	+	+
Family: Desmidiaceae												
Closterium kuetzingii			+	+	+	+				+		
C. moniliferum						+	+	+	+	+		
C. lunula							+	+		+		
C. ralfsii			+		+				+	+		
Spirotaenia spp.										+		
Order: Oedogoniales												
Family: Oedogoniaceae												
Oedogonium spp.						+						
Order: Chaetophorales												
Family:Chaetophoraceae												
Stigeoclonium flagelliferum						+			+		+	+
S. subsecundum									+			
Order: Volvocales												
Family: Chlamydomonadaceae												
Chlamydomonas globosa						+				+	+	
Family: Volvocaceae												
Pandorina morum								+				
Order: Ulotrichales												
Suborder: Ulotrichineae												
Family: Ulotrichaceae												
Ulothrix zonata									+			
Dinoflagellata												
Class: Dinophyceae												
Order: Peridiniales												
Family: Ceratiaceae												
Ceratium hirundinella	+	+										
C. birundinella	+	+										
Xanthophyta												
Class: Xanthophyceae												
Order: Vaucheriales												
Family: Vauchericeae												

Vaucheria spp.										+		
Euglenophyta												
Class: Euglenophyceae												
Order: Euglenales												
Family: Euglenaceae												
Euglena deses										+		
E. klebs										+		
Bacillariophyta												
Class:Centrobacillariophyceae												
Order: Eupodiscales												
Family:Consinodiscaceae												
Melosira cranulata	+	+	+	+			+	+	+	+	+	+
M. varians	+	+		+			+	+	+	+	+	+
Aulacosira granulata	+	+				+	+		+	+	+	+
Order: Fragilarialles												
Family: Fragilariaceae												
Subfamily: Diatomoideae												
Diatoma vulgare	+	+	+	+	+	+	+	+	+	+	+	+
Subfamily: Fragilarioideae												
Fragilaria crotonesis	+	+	+	+	+	+		+	+	+	+	+
F. ulna	+	+	+	+	+	+	+	+	+	+	+	+
Synedra ulna	+			+	+	+			+	+	+	+
Order: Achnanthales												
Family: Achnanthaceae												
Subfamily: Achnanthoideae												
Cocconeis pediculus			+	+	+	+	+	+	+	+	+	+
Rhoicosphena abbreviata				+		+	+	+	+	+	+	+
Order: Naviculales												
Family: Naviculaceae												
Subfamily: Naviculoideae												
Gyrosigma attenuatum	+	+				+	+		+	+	+	+
Navicula tripunctata	+	+	+	+	+	+	+		+	+	+	+
N. trivialis	+	+	+	+	+	+		+	+	+	+	+
Family: Cymbellaceae												
Amphora copulate							+	+	+	+	+	+
Encyonema prostratum	+	+	+		+			+	+	+	+	+
Didymosphenia geminate		+							+	+	+	+
Cymbella aspera	+	+	+	+	+	+	+		+	+	+	+
C. tumida	+	+	+	+		+	+	+	+	+	+	+
C. lange-bertalotii	+		+	+		+	+	+	+	+	+	+
Family: Gomphonemaceae												
Gomphonema pumilum	+			+		+	+	+	+	+	+	+
Family: Amphipleuraceae												
Frustulia rhomboids	+	+	+		+			+	+	+	+	+
Family: Sellaphoraceae												
Sellaphora pupula		+		+			+		+	+	+	+
Family: Stauroneidaceae												
Craticula ambigua								+	+	+	+	+
Order: Bacillariales												
Family: Nitzschiaceae												
Nitzschia palea	+	+	+		+	+	+	+	+	+	+	+
Order: Surirellales												
Family: Surirellaceae												
Cymatopleura solea						+	+		+	+	+	+
C. elliptica									+	+	+	

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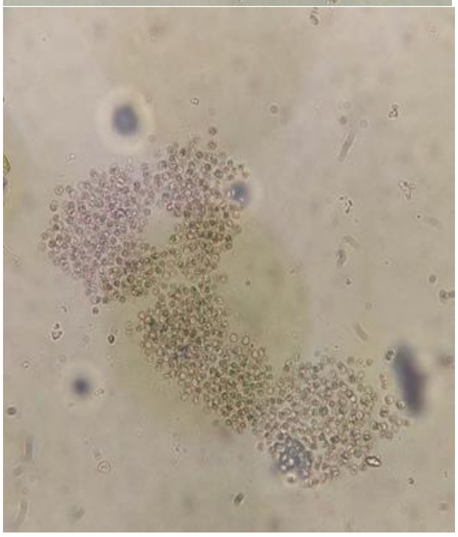
2

3



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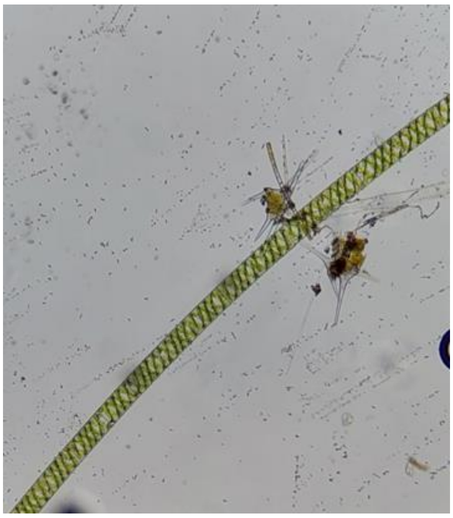

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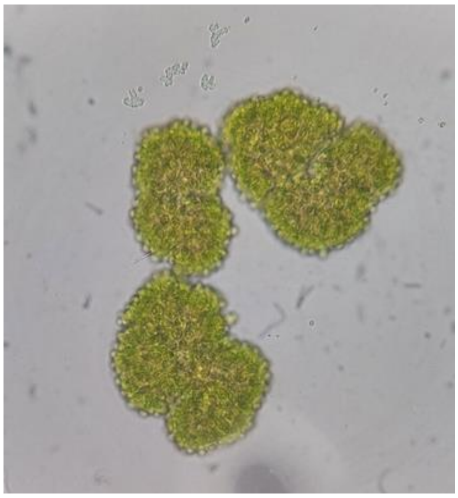

9

Plate (1): 1. *Oscillatoria subbrevis* Schmidle 2. *Microcystis aeruginosa* (Kuetz.) 3. *Euglena deses* Ehrenberg 4. *Ceratium hirundinella* (O. F. Muell) 5. *Spirogyra spp*. 6. *Pediastrum simplex* var. duodenarium 7. *P. duplex* var. reticulatum 8. *Botryococcus braunii* Kuetzing 9. *Oedogonium spp.*

1

2

3

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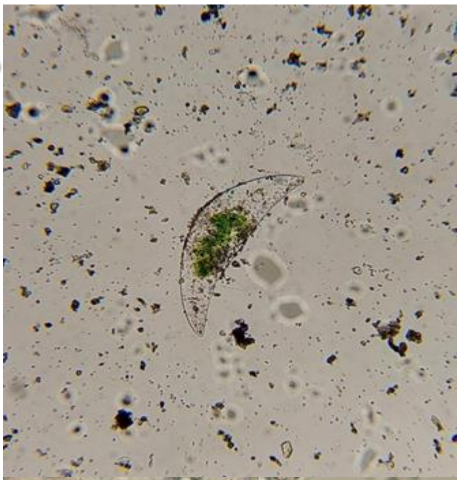

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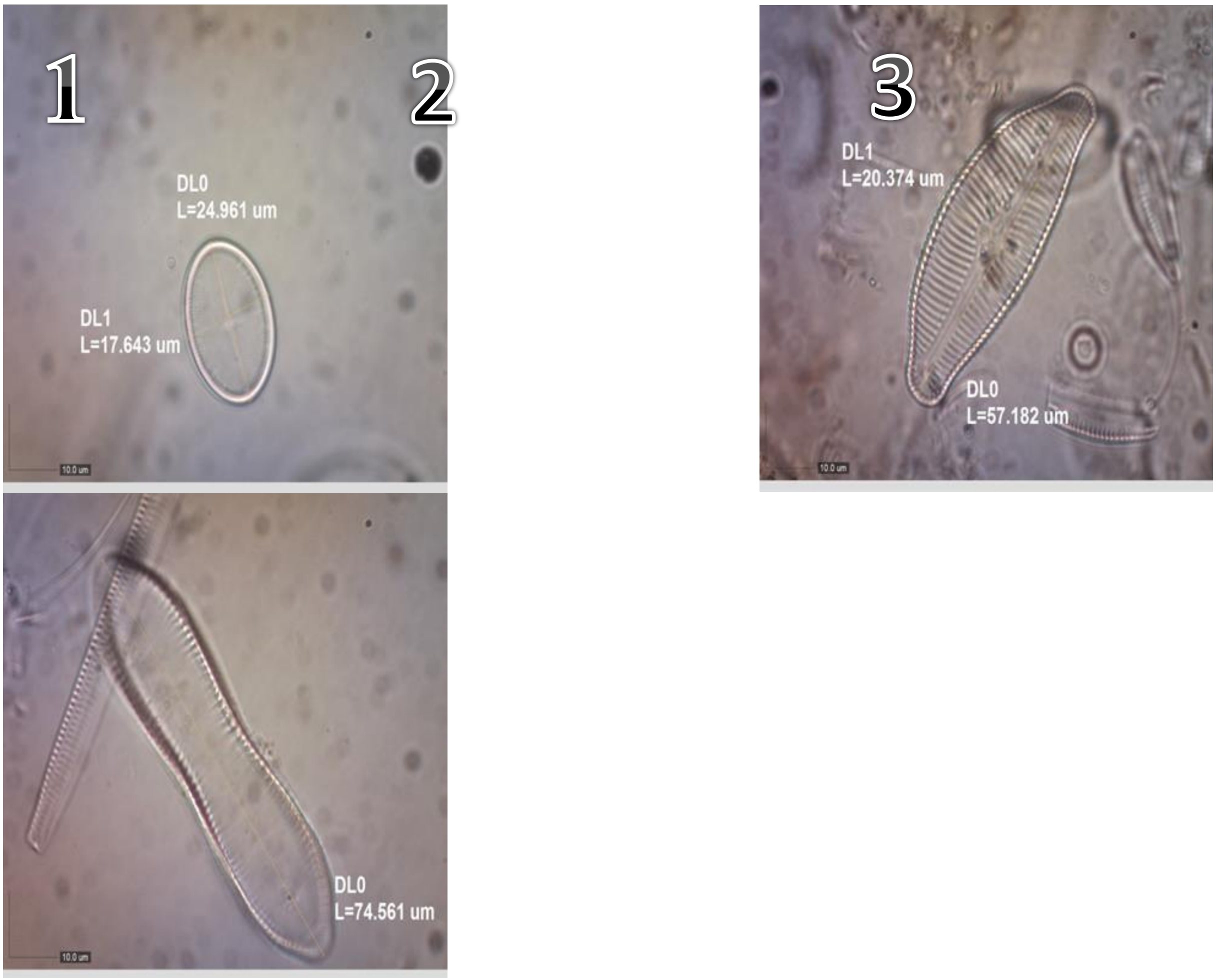
Plate 2: 1. *Cladophora fracta* (Dillw.) Kuetzing 2. *C. fracta* var. normalis Rabenhorst ex Heering 3. *Stigeoclonium flagelliferum* Kuetzing Ehrenberg 4. *Closterium moniliferum* 5. *C. lunula* var. biconvexum 6. *Pandorina morum* (Muell.) Bory 7. *Vaucheria spp* 8. *Aulacosira granulata* (Ehrenberg) 9. *Amphora copulata* (Kuetzing).


1
2
DL0
L=24.961 um
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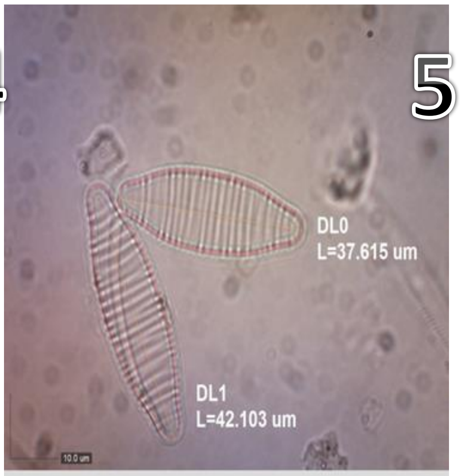

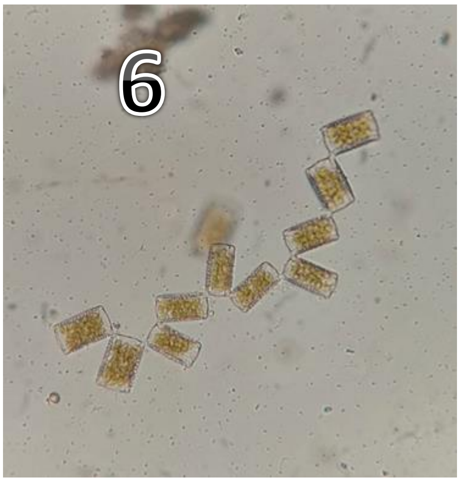

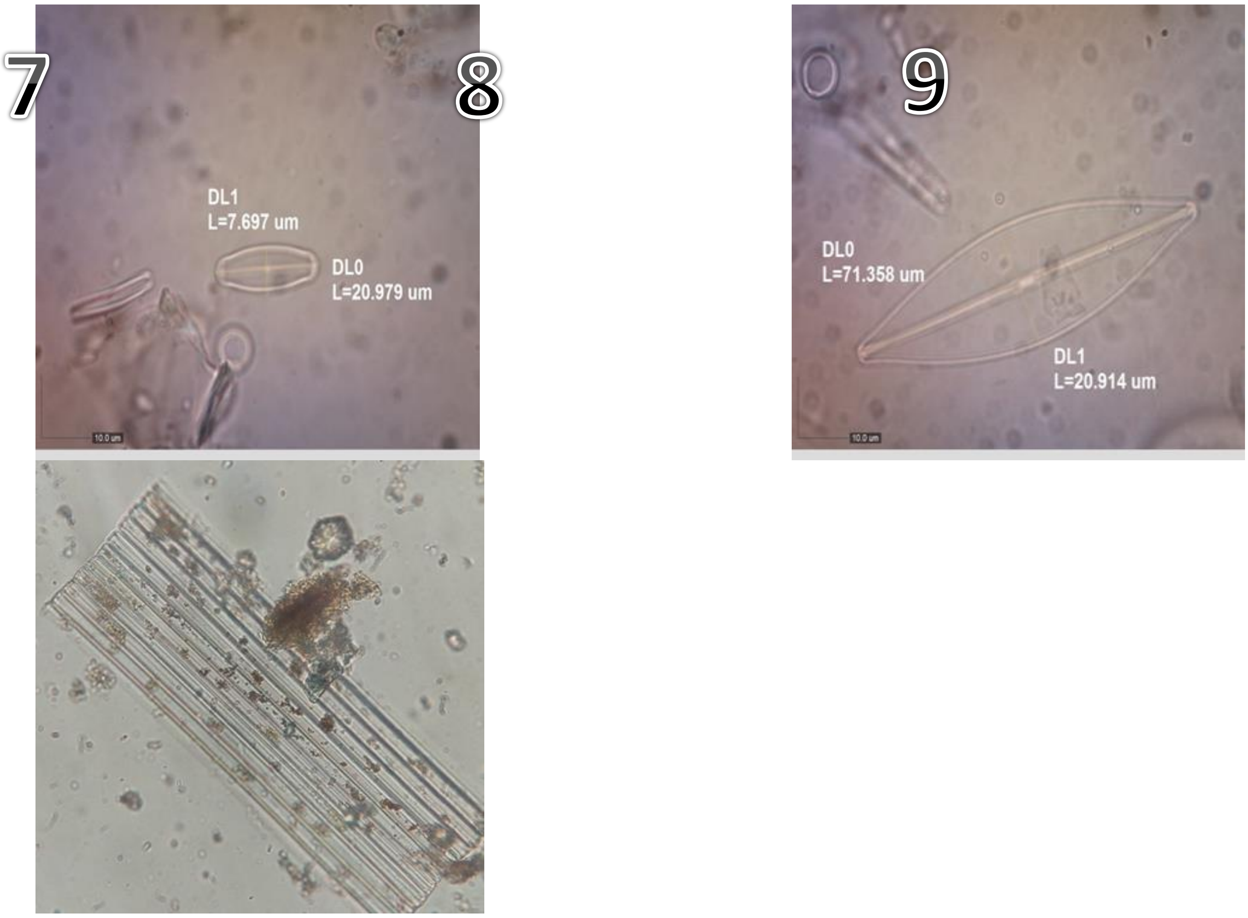

Plate 3: 1. *Cocconeis pediculus* (Ehrenberg) 2. *Encyonema prostratum* (Berkeley) Kuetzing.3. *Cymatopleura solea* (Brebisson) 4. *Diatoma vulgare* Bory 5. *D. vulgare* Bory girdle view 6. *Gomphonema pumilum* (Grunow) 7. *Sellaphora pupula* (Kuetzing).8. *Frustulia rhomboids* var. crassinerva 9. *Fragilaria crotonensis* Kitton.

4. CONCLUSION

1. The pH of water in the studied area was on the alkaline side.
2. The studied river was (hard water) during study periods.
3. In general, river flooding has a negative impact on water quality by reducing the diversity and amount of algae.
4. Filamentous green algae (*Cladophora* and *Spirogyra*) prefer low current velocity water that is removed from rivers by runoff.
5. Bacillariophyta was the dominant phytoplankton during the study period.
6. High values of nutrients (PO_4, NO_3, and SiO_2) were recorded during in the studied lake.

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کەڤز وەک نیشاندەرێ زیندی ژبو هلسەنگاندن و بنچاڤک رنا کوالّتیا ئاڤێ ب تایبەت بنگەهێ ئاڤا ڤەخوارنێ یا دهوکێ

پوختە

ڤەکولین ل سەرپیڤەرێن فیزیایی، کیمیایی، و بایولوجی هاتنە کرن ل شەش بنگەهێن نموونەکرنێ یێن ژێگرتی ل بنگەهێ ئاڤا ڤەخوارنێ یا دهوکێ ل باژێرێ دهوکێ. نموونێن کەڤزێ و یێن ئاڤێ هاتنە کومکرن هەیڤانە ژ تشرینا ئێکێ 2021 تا ئەیلولا 2022 هندەک پیڤەرێن فیزیایی و کیمیایی یێن دەڤەرا ڤەکولینێ هاتنە دیارکرن. پلا گەرمیا ئاڤێ دناڤبەرا 8.1 تا 22.5 س دا بوو. پلا ئە یونین هیدروجینی د جودا بوون ژ 7.31 تا 8.93. گەهێنەریا کارەبێ یا تایبەت ژ 328.1 تا 472.6 میکرو سیمنس سم-1. پلا ئە لکالی ژ 120 تا 195 ملکم کاربونات الکالسیوم / لتر. کشت حلوبونێ یا جودا بوو ژ 184 تا 250 ملکم کاربونات الکالسیوم / لتر ، ل دویف ئەنجامێن ئەڤێ ڤەکولینێ دەریاچەیا ڤەکولین ل سەر هاتیە کرن ئاڤا وێ یا توند بوو. پلا سیلیکاتی ژ 67.89 تا 120.01 ملکم / لتر بوو. فوسفات ژ 0.01 تا 0.73 بوو ملکم / لتر بوو. نیترات ژ 2.3تا 5.8 ملکم / لتر بوو. سەرجەمێ ٥٨ ڕەگەز و جورێن کەڤزێ هاتنە دەستنیشانکرن د ئەڤێ ڤەکولینێ دا، کو بو شە ش جوینان دزڤرن (25 جور) سەر ب **Bacillariophyta** بوون، کو تا 43٪ ژ سەرجەمی پێک دئینیت، (21 جور) سەر ب **Chlorophyta**، کو 36٪ ژ سەرجەمی پێک دئینیت، (7 جور) سەر ب **Cyanophyta**، کو 12٪ ژ سەرجەمی پێک دئینیت، (2 جور) سەر ب **Euglinophyta**، کو 3.5٪ پێک دئینیت, (2 جور) سە ر ب **Dinoflagellata**, کو 3.5% پێک دئینیت, (1 جور) سە ر ب **Xanthophyta**, کو 2% پێک دئینیت.

استخدام الطحالب كمؤشر لتقييم و مراقبة نوعية المياة خاصة فيما يتعلق بمشروع مياة الشرب في دهوك

الخلاصة

تـم دراسـت الصـفات الفيزيائيـة والكيميائيـة والبيولوجيـة فـي سـت مواقـع مختـارة لأخـذ العينـات فـي مشـروع ميـاة دهـوك المـائي فـي مدينـة دهـوك. وجمعـت عينـات الطحالـب والميـاه شـهريا مـن تشـرين الأول/أكتـوبر 2021 إلـى أيلـول/سـبتمبر 2022. وتـم تحديـد بعـض الصـفات الكيميائيـة والفيزيائيـة للمنطقـة المشـمولة بالدراسـة. وتراوحـت درجـات حـرارة الميـاه بـين 8.1 و22.5 درجـه سـيليزيهة. وتباينـت قـيم ايـون الهيـدروجين مـن 7.31 إلـى 8.93. وتراوحـت القابليـة الكهربائيـة النوعيـة بـين 328.1 و472.6 ميكـرو سـيمنس سـم-1. وتراوحـت قيمـة القاعديـة بـين 120 و195 ملغـم كربونـات الكالسـيوم/ لتـر. وتباينـت العسـرة الكليـة مـن 184 إلـى 250 ملغـم كربونـات الكالسـيوم/ لتـر ، وفقـاً للنتـائج التـي تـم الحصـول عليهـا مـن هـذه الدراسـة فـإن البحيـرة التـي أجريـت عليهـا الدراسـة كانـت مياههـا عسـرة. وتراوحـت قـيم السـيليكات بـين 67.89 و120.01 ملغـم/ لتـر. وتراوحـت قـيم الفوسـفات بـين 0.01 و0.73 ملغـم/لتـر. وتباينـت قـيم النيتـرات مـن 2.3 إلـى 5.8 ملغـم/ لتـر. وقـد تـم خـلال هـذه الدراسـة تحديـد مجموعـة مـن 58 نوعـاً مـن مجمـوع الطحالـب التـي تنتمـي إلـى سـت شـعب (25 صـنفا) تنتمـي إلـى الطحالـب العصـوية، ممـا يشـكل 43 فـي المائـة مـن المجمـوع، (21 صـنفا) تنتمـي إلـى الطحالـب الخضـراء، ممـا يشـكل 36 فـي المائـة مـن المجمـوع، (7 اصـناف) تنتمـي إلـى الطحالـب الخضـر المزرقـة، ممـا يشـكل 12 فـي المائـة مـن المجمـوع، و2 صـنفين ينتمـون إلـى الطحالـب اليوغلينيـة، ممـا يشـكل 3.5 فـي المائـة، 2 صـنفين ينتمـون الـى الطحالـب سـوطيات الـدوارة، ممـا يشـكل 3.5 فـي المائـة، وصـنف واحـــد ينتمـــي الـــى الطحالـــب الصـــفراء المخضـــرة، ممـــا يشـــكل 2 فـــي المائـــة.